1994 Cancer Incidence in Washington

Annual Report of the
Washington State Cancer Registry

September 1997

Office of Community Wellness and Prevention

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Executive Summary

This annual report of the Washington State Cancer Registry is the third publication to include cancer incidence data covering the entire state. It represents the ongoing effort by the Department of Health, the Fred Hutchinson Cancer Research Center, the Blue Mountain Oncology Program, physicians, and tumor registrars throughout Washington.

Cancer is a heterogeneous group of diseases characterized by uncontrolled growth and spread of abnormal cells. The various forms of cancer were responsible for 9,797 deaths among Washington residents in 1994, comprising twenty-five percent of all deaths. In 1994, cancer (all sites combined) was the most common cause of death among adults ages 35 to 74 years and the second leading cause overall. With 25,015 cases of cancer diagnosed in the state in 1994, some form of cancer will likely strike one in three Washingtonians in their lifetime.

This report of the Washington State Cancer Registry (WSCR) summarizes information on new cases of cancer (incidence) and death due to cancer (mortality) for Washington state residents. The report provides information on cancer of all sites combined and the 24 cancer sites most frequently diagnosed in Washington residents. This information can be used at the state, county or regional level to identify the burden of morbidity and mortality associated with each type of cancer. This information, combined with information on cancer prevention, early detection, and treatment, is useful for program planning and policy development aimed at reducing the burden of cancer.

The five most common types of cancer reported among Washington residents during 1994 were breast, prostate, lung, colorectal, and melanoma.

1 4,221 new cases and 745 deaths from female breast cancer were reported in 1994. Breast cancer is the second most common cause of cancer mortality for women. Nationally, breast cancer incidence has been increasing approximately 1% per year for the past 50 years. (NCI, 1997) The best strategy for prevention of breast cancer mortality is early detection through screening.

2 3,408 new cases and 662 deaths from prostate cancer were reported in 1994. It is the second leading cause of cancer death among men. Increased detection through screening most likely contributes to recent increases in prostate cancer incidence. (NCI, 1997) Screening has yet to demonstrate clear benefit in reducing death from prostate cancer. (NCI, 1997)

3 3,386 new cases of lung cancer were reported. 2,829 Washingtonians died of lung cancer, making it the leading cause of cancer mortality. Reduction in smoking remains the major focus of efforts to prevent lung cancer.

4 2,670 new cases of and 1,007 deaths from colorectal cancer were reported in 1994. Nationally, the incidence of colorectal cancer is increasing while the mortality rate is decreasing. (NCI, 1997) Regular screening has been shown to reduce mortality. (NCI, 1997) Regular physical activity and a low fat, high fiber diet rich in fruits and vegetables may reduce the risk for colon and rectum cancer. (ACS, 1996; CDC, 1996)

5 1,275 new cases and 106 deaths from melanoma of the skin were reported in 1994. Nationally, the incidence of melanoma has been increasing for several decades. (NCI, 1997) Avoiding sunburn and routine examination of the skin are effective in reducing incidence and mortality from melanoma. (NCI, 1997)

Preface

This annual report of the Washington State Cancer Registry is the third publication to include cancer incidence data covering the entire state. It represents the ongoing effort by the Department of Health, the Fred Hutchinson Cancer Research Center, the Blue Mountain Oncology Program, physicians, and tumor registrars throughout Washington. These data are presented in the hope that they will assist health care providers, public health officials, voluntary organizations, and concerned citizens in their efforts to prevent and control cancer in Washington.

Introduction

Cancer is a heterogeneous group of diseases characterized by uncontrolled growth and spread of abnormal cells. The various forms of cancer were responsible for 9,797 deaths among Washington residents in 1994, comprising twenty-five percent of all deaths. In 1994, cancer (all sites combined) was the most common cause of death among adults ages 35 to 74 years and the second leading cause overall. With 25,015 cases of cancer diagnosed in the state in 1994, some form of cancer will likely strike one in three Washingtonians in their lifetime.

Illness and death due to cancer are increasingly preventable through two types of strategies. Primary prevention strategies aim to reduce, usually through lifestyle change, the likelihood that a healthy individual will develop cancer. Alternatively, secondary prevention is accomplished by screening asymptomatic people to diagnose cancers at an early, more readily treatable stage.

This report of the Washington State Cancer Registry (WSCR) summarizes information on new cases of cancer (incidence) and death due to cancer (mortality) for Washington state residents. The report provides information on cancer of all sites combined and the 24 cancer sites most frequently diagnosed in Washington residents. This information can be used at the state, county or regional level to identify the burden of morbidity and mortality associated with each type of cancer. This information, combined with information on cancer prevention, early detection, and treatment, is useful for program planning and policy development aimed at reducing the burden of cancer.

The Five Most Common Cancer Sites

The most common types of cancer reported among Washington residents during 1994 were breast, prostate, lung, colorectal, and melanoma.

1 4,221 new cases of female breast cancer were reported. Breast cancer is by far the most frequently diagnosed cancer among women. Responsible for 745 deaths in 1994, it is the second most common cause of cancer mortality for women. Nationally, breast cancer incidence has been increasing approximately 1% per year for the past 50 years. (NCI, 1997) Because the cause of most breast cancer is unknown and the known risk factors are not easy to modify, the best strategy for prevention of breast cancer mortality is early detection and treatment. While experts do not agree on the benefits of mammography screening for women under 50 years old, regular breast cancer screening with mammography and clinical breast exam reduces the number of deaths from breast cancer for women age 50 and older. (NCI, 1997) The American Cancer Society recommends clinical breast exam and mammography for women between 40 and 49 years old. (ACS, 1995) While evidence about the efficacy of self-breast exam is mixed (NCI, 1997), the American Cancer Society recommends monthly self-breast exams beginning at age 20. (ACS, 1995)

2 3,408 new cases of prostate gland cancer were reported, making prostate cancer the second most commonly diagnosed malignancy overall, and the most commonly reported malignancy among men. It is the second leading cause of cancer death among men, killing 662 men in 1994. Nationally, both incidence and mortality rates for prostate cancer have been increasing. (NCI, 1997) Increased detection through screening most likely contributes to the more recent increases in prostate cancer incidence. (NCI, 1997) No effective means are currently available to prevent the development of this cancer. Unfortunately, prostate cancer screening has yet to demonstrate clear benefit in reducing the death toll. (NCI, 1997)

3 3,386 new cases of lung cancer were reported. 2,829 Washingtonians died of lung cancer, making it the leading cause of cancer mortality. Cigarette smoking is by far the most important cause of lung cancer. Nationally, approximately 90% of male and 72% of female lung cancer deaths are attributed to smoking. (CDC, 1997) Studies have failed to provide evidence that screening can reduce mortality. Reduction in smoking remains the major focus of efforts to prevent lung cancer.

4 2,670 new cases of colon and rectum cancer were reported. Colorectal cancer is the state's second leading cause of cancer death, resulting in the loss of 1,007 lives in 1994. Nationally, the incidence of colorectal cancer is increasing while the mortality rate is decreasing. (NCI, 1997) Regular screening of the stool for invisible amounts of blood beginning at age 45 and regular visual examination of the lower bowel (sigmoidoscopy) beginning at

age 50 have been shown to reduce mortality. (NCI, 1997) Research evidence indicates that regular physical activity and a low fat, high fiber diet rich in fruits and vegetables may reduce the risk for colon and rectum cancer. (ACS, 1996; CDC, 1996)

5 1,270 new cases of melanoma of the skin were reported. Melanoma accounted for 106 deaths in Washington residents. Nationally, the incidence of melanoma has been increasing for several decades. (NCI, 1997) There is evidence that avoiding sunburns, especially during childhood and adolescence, may be effective in preventing melanoma. (NCI, 1997) There is also evidence that routine examination of the skin is effective in reducing mortality from melanoma. (NCI, 1997)

Washington State Cancer Registry

Background

In 1990, RCW 70.54.230 made cancer a reportable condition in Washington and mandated the Department of Health to establish a statewide cancer registry program. Under this mandate, the Department established the Washington State Cancer Registry (WSCR) in 1991. The registry is dedicated to fulfillment of the legislative intent "...to establish a system to accurately monitor the incidence of cancer in the state of Washington for the purposes of understanding, controlling, and reducing the occurrence of cancer in this state." In 1995, WSCR received funding through the Centers for Disease Control and Prevention's National Program of Central Cancer Registries. This program is designed to standardize data collection and provide information for cancer prevention and control programs at the local, state and national levels.

Data Collection

WSCR began its operations in July of 1991 and contracts for data collection with two regional tumor registries that together cover the entire state. The contractors are responsible for case-finding, abstracting information on cancer cases in their respective regions, and reporting to the statewide registry. The Cancer Surveillance System (CSS) of the Fred Hutchinson Cancer Research Center provides data on cancer cases from 13 counties in Western Washington, covering the majority of the state's population including the largest urban center of Seattle. CSS has been in operation since 1974 as a participant in the Surveillance Epidemiology and End-Results (SEER) Program of the National Cancer Institute (NCI). The Walla Walla-based Blue Mountain Oncology Program (BMOP), under contract with the Department of Health, has expanded the activities of its 14 facility-based registry to cover the remainder of the state. BMOP also conducts regular data exchanges with hospitals in Oregon and Idaho to gather data on Washington residents traveling across state lines for cancer diagnosis and treatment.

The contractors receive reports of cancer cases from hospitals, pathology laboratories, radiation oncology centers, ambulatory surgical centers, cancer treatment centers and physicians. Contract staff complete data abstraction on all reported cases or collect abstracts from hospital tumor registrars who complete them. The contractors also carry out quality assurance activities and provide WSCR with data tapes on a regular basis. WSCR is responsible for merging the data and finalizing the statewide data set, overall data quality assurance in accordance with national standards, and dissemination of cancer information to assist with cancer prevention and control efforts statewide.

The cancer reporting rules (246-430 WAC) define reportable cancer cases as "any malignant neoplasm, with the exception of basal and squamous cell carcinoma of the skin". Also specifically included are: 1) basal and squamous cell carcinoma of the external genital organs (vulva, labia, clitoris, prepuce,

penis, anus, scrotum); 2) all brain tumors; 3) ovarian tumors of borderline or low malignant potential and 4) cancer in-situ, except cancer in-situ of the uterine cervix. The legally required data for cancer reporting include demographic and medical information about all newly diagnosed cases. Copies of Washington's cancer reporting legislation and regulations are available on request.

Report Contents

This report summarizes incidence and mortality data on all cancers and on the 24 cancer sites most frequently diagnosed in Washington residents. The following sections briefly describe each of the tables, graphs and charts in this report; the statistical methods used to produce each table, graph or chart; and special considerations for interpreting the data. The main body of this report consists of eight-page sections on each of the selected malignancies. Finally, appendices include technical notes and sources of information on the epidemiology and prevention of cancer.

The primary focus of the eight-page sections is on cases newly diagnosed between January 1, 1994 and December 31, 1994. These data cover the entire state, and, unlike previous reports, include new cases of cancer among Washington residents diagnosed in Oregon. Since WSCR did not have formal case-sharing agreements in place with Idaho and other states until 1996, cases diagnosed and treated solely outside of Washington may be missing. Mortality data include deaths which occurred in 1994 where the underlying cause of death was cancer. The cancer may have been diagnosed before 1994.

Tables, Charts and Graphs

Data Definitions and Sources

The Washington State Cancer Registry provides the number of new cases (incidence) of cancer as described above. Based on estimates of the expected number of cancer cases, the registry includes more than 95% of cases. Each cancer is coded to an International Classification of Diseases Oncology (ICD-O) code. The data definition provides the ICD-O codes used in each section. We have used definitions which are consistent with those used by the NCI's SEER program.

The Washington State Department of Health, Center for Health Statistics provides information on the number and causes of death from the death certificate. According to the National Center for Health Statistics (NCHS), more than 99% of all deaths occurring in the United States are registered in the death certificate system. Accuracy of reporting specific causes of death varies since classification of disease conditions is a medical-legal opinion subject to the best information available to the physician, medical examiner, or coroner certifying the cause of death. We obtained the number of cancer deaths from the Vital Registration System Annual Statistical Files, Washington State Deaths 1980-1995 CD-ROM issued October 1996.

The underlying cause of death is coded to an International Classification of Diseases, 9th Revision (ICD-9) code. The data definition provides the ICD-9 codes used in each section. We have used definitions which are consistent with those used by the SEER program. For some cancer sites, including colorectal, liver, breast and non-Hodgkin's lymphoma, the SEER coding differs from the NCHS coding which may be used in other Department of Health reports. Therefore, before comparing information from different reports, one must be sure that the definitions are consistent.

We obtained population estimates necessary for the calculation of rates from the Washington State Department of Social and Health Services, Research and Data Analysis. These estimates, called Washington State adjusted population estimates, were released in June 1997 and are based on estimates by Claritas, Inc. and the Washington State Office of Financial Management (OFM). Minor differences at the state and county level between these population estimates and those released by OFM in January, 1997, are due to rounding.

Incidence and Mortality Summary

These tables provide the number of new cases and deaths for Washington State residents in 1994. Since the numbers of new cases and deaths depend, in part, on the size of the population, we converted numbers to rates (e.g., the number of cases per 100,000 people) so that they may be compared among different regions or populations. For diseases, such as cancer, where incidence varies

with age, the rates are usually age-adjusted to minimize the effect of differing age distributions when comparing two geographic regions or populations. Following NCI guidelines, we have adjusted rates per 100,000 population for Washington residents to the US 1970 standard population. More detail on our age-adjustment method is provided in Appendix A. For incident cases, we have provided age-adjusted rates for all cancers and for invasive cancers (see Stage at Diagnosis below). The latter figures are provided to enable comparisons between Washington and the United States.

The final row of each table provides age-adjusted rates for the United States. The incidence rates are from the SEER homepage using the CANQUES program. Except for bladder cancer, these rates include only cases of invasive cancer. The US mortality data were derived from the CDC WONDER program.

Stage at Diagnosis

Stage at diagnosis refers to how far a cancer has spread from its site of origin when it is diagnosed. The stages, in order of increasing spread, are in situ, local, regional and distant. Cancers staged as local, regional or distant are referred to as invasive.

The WSCR data contain the stage of disease at diagnosis coded according to the SEER guidelines.

In Situ	A tumor that fulfills all microscopic criteria for malignancy, but does not invade or penetrate surrounding tissue.
Localized	A tumor that is invasive but remains restricted to the site of origin.
Regional	A tumor that has spread by direct extension to immediately adjacent organs or tissues and/or metastasized (spread through the blood stream) to regional lymph nodes, but appears to have spread no further.
Distant	A tumor that has spread by direct extension beyond the immediately adjacent organs or tissues, and/or metastasized to distant lymph nodes or other distant tissues.
Unknown	Insufficient information available to determine the stage of disease at diagnosis.

We have provided the percent distribution of cases according to their stage of disease at diagnosis.

For most cancers, diagnosis at an early stage (in-situ or local) results in improved survival. Due to the newness of WSCR, we have not developed five-year survival rates for Washington state residents. However, we have provided

the national five-year survival rate (i.e., the proportion of individuals with a given cancer remaining alive five years after diagnosis) for each cancer. These data were obtained from the SEER CANQUES program and provide survival rates both for all invasive stages combined (local, regional and distant) and for local stage at diagnosis.

Age-Specific Incidence Rates

Age-specific rates show the variation in cancer incidence by age group for males, females and the total population.

Incidence and Mortality Rate Trends

These charts provide incidence and mortality rates for several years for Washington residents per 100,000 population, age-adjusted to the US 1970 standard population. (See “Incidence and Mortality Summary” for a discussion of age-adjusted rates.) These tables show both how the rates vary over time and the relationship of cancer incidence and mortality. However, given only three years of incidence data, one needs to be cautious in interpreting the trends for cancer incidence. As more years of data accrue, this type of information will become increasingly helpful in determining whether incidence is increasing, decreasing or remaining constant.

Incidence and Mortality Rates by PUMS Regions

The Public Use Micro-Data Set (PUMS) regions, were developed by the state Office of Financial Management in collaboration with the United States Census Bureau. Each PUMS region had a minimum population of 100,000 in 1990. Under this scheme, the state's nine largest counties are considered individually. The remaining counties are grouped with an attempt to maintain, to the extent possible, cultural and socio-economic similarity within regions. The regions are listed below.

Region 1	Whatcom
Region 2	Island, San Juan, Skagit
Region 3	Chelan, Douglas, Kittitas, Okanogan
Region 4	Kitsap
Region 5	Clallam, Jefferson, Mason
Region 6	Snohomish
Region 7	King
Region 8	Pierce
Region 9	Thurston
Region 10	Grays Harbor, Lewis, Pacific
Region 11	Clark
Region 12	Cowlitz, Klickitat, Skamania, Wahkiakum
Region 13	Adams, Ferry, Grant, Lincoln, Pend Oreille, Stevens

Region 14	Spokane
Region 15	Benton, Franklin
Region 16	Yakima
Region 17	Asotin, Columbia, Garfield, Walla Walla, Whitman

We have presented age-adjusted 1994 cancer incidence and mortality rates for Washington residents per 100,000 population by PUMS regions. (See "Incidence and Mortality Summary" for a discussion of age-adjusted rates.) The state rates and 95% confidence intervals are included for comparison purposes. While the incidence and death data in this report are not subject to sampling error, they may be affected by random variation. The confidence interval is used to describe the range of that variation. The 95% confidence interval describes the range of rates which have a 95% probability of containing the "true" rate.

Generally, when the confidence interval for the area of interest does not overlap with the confidence interval for the comparison area, we say that the two areas are statistically significantly different, i.e., the difference between the two rates is more than that expected by random variation or chance. However, if we are making many comparisons, we may still find what appear to be statistically significant differences just by chance. In fact, with a 95% confidence interval, we expect that 5% of the comparisons will appear to be statistically significant by chance. Thus, with 17 PUMS regions and 24 cancer sites, we would expect to see about 20 instances where the rate for a PUMS region appeared to be statistically significantly different from the state rate just by chance.

Because the rate is not stable when there are a small number of cases, the rate and confidence intervals are omitted when there are fewer than 5 cases. Details of our methods for developing confidence intervals are in Appendix A.

Incidence and Mortality Rates by County

These data are presented in a similar manner to the data for the PUMS regions. However, because of the small size of many counties and the relative rarity of some types of cancer, we are unable to compute a rate due to the small number of cases for many of the counties when we use only one year of data. Therefore, we have combined three years of data (1992-1994) and computed annual average age-adjusted rates. (See section "Incidence and Mortality by PUMS Regions" for technical details and notes on interpretation.)

Data Tables

Each section ends with three pages of data tables. These tables provide data by county and PUMS region. The county table provides the number of new cases and the average annual number of deaths for 1992-1994. The table also includes incidence and mortality rates with the 95% confidence interval, age-adjusted to both the 1940 and 1970 US standard populations. (See "Incidence and Mortality Summary" for a discussion of age-adjusted rates. See "Incidence

and Mortality Rates by PUMS Regions" for a discussion of confidence intervals.) Age-adjustment using these standards is included so that the data are comparable to data from NCI, which adjusts to the 1970 US standard population and to data from the NCHS at CDC which generally adjust to the 1940 US standard population. However, caution must be used in making comparisons among different sources, since coding of cancer sites varies. In particular, we have noted differences in definitions between NCI and NCHS for colorectal, breast, liver and non-Hodgkin's lymphoma.

The tables for the PUMS regions include the same information as the county tables, except that these data are for only 1994. They also include figures for males and females separately.

What's Missing

Race Groupings

The cancer reporting rules require that the race of each case be included in the data provided to WSCR. However, special studies linking Indian Health Services data to WSCR have revealed that Native Americans are often reported as Caucasians and are therefore, underreported in WSCR. There have not been special studies for other racial and ethnic groups and so we do not know whether other groups are accurately reported. Therefore, we have not included information by race and ethnicity in this report. We will continue to assess the accuracy of reporting with the goal of including this information in future reports.

Information on Prevention, Early Detection and Treatment

Illness and death due to cancer are increasingly preventable through the application of growing knowledge about the causes of cancer, improved screening and early diagnosis techniques, and more effective treatment. Extensive information on prevention though changing modifiable risk factors, early detection through routine screening, and preferred treatment modalities is available. We have not attempted to reproduce this information in detail. However, a brief summary of the most important public health aspects of cancer prevention and control follows in the paragraphs below. We have provided a resource list in Appendix B for those interested in more detail.

Screening for early detection has a clear role in reducing the disease burden due to cancer of the female breast, the uterine cervix and colorectal cancer (NCI, 1997). There is also evidence that routine examination of the skin is effective in reducing mortality from melanoma. (NCI, 1997)

Major reductions in cancer rates, and in an individual's likelihood of developing cancer, are achievable through primary prevention strategies. The elimination of tobacco use would markedly reduce the incidence lung cancer and reduce the incidences of cancer of the oral cavity and pharynx, esophagus, bladder, kidney, and pancreas. (Schottenfeld and Fraumeni, 1996) Cancers of other sites, especially those of squamous cell, such as squamous cell cancer of the uterine cervix, may also be reduced by elimination of tobacco use. (Schottenfeld and Fraumeni, 1966). A diet low in fat, high in fiber and including five or more servings per day of fruits and vegetables is likely to reduce the risk for cancer of the colon and rectum, oral cavity, esophagus and stomach (Schottenfield and Fraumeni, 1996) and possibly reduce the risk of breast cancer (NCI, 1997). Additional studies have shown beneficial effects of a diet rich in fruits and vegetables for prevention of cancer at other sites, such as uterine cervix, ovary, endometrium, lung, larynx, and other organs, but the scientific literature for these sites is not as extensive and/or consistent as for the sites previously listed. (Schottenfeld and Fraumeni, 1996) Regular, moderate exercise has also shown evidence of benefit in the prevention of cancer at a number of sites, such as colorectal and breast (NCI, 1997). The overall health benefit of these habits, and

their lack of countervailing risk, makes them wise choices for cancer prevention. Health care providers, public health agencies and voluntary organizations can provide the education which helps people make healthy choices.

While individual behavior plays an important role in cancer prevention, governmental and other societal entities have key roles as well. Policies and regulations that, for example, ban cigarette smoking, reduce youth access to tobacco, assure delivery of health services and control occupational exposures are important for preventing and controlling cancer.

References

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American Cancer Society. Breast Cancer Facts and Figures 1996. December 1995.

Centers for Disease Control and Prevention, Office on Smoking and Health. Smoking Attributable Morbidity and Mortality and Economic Costs version 3.0 (SAMMEC 3.0.). 1997.

Centers for Disease Control and Prevention. Colorectal Cancer: The Importance of Early Detection. At-A-Glance. 1996

National Cancer Institute. PDQ Detection and Prevention website (http://icicc.nci.hih.gov/clinpdq/screening.html). September 1997.

Schottenfeld, David and Fraumeni, Joseph F. Jr. Cancer Epidemiology and Prevention, Second Ed. Oxford University Press, 1996.

Appendix A: Technical Notes

Age-Adjustment

Age-adjusted incidence rates were developed using the direct method. They were standardized to the age distribution of the United States 1970 and 1940 populations. Following the age-adjustment procedures used by the National Cancer Institute, which uses the US 1970 standard population for age-adjustment, we used five year age groups in calculating age-adjusted rates with the 1970 US standard population. For age-adjustment with the 1940 US standard population, we followed the methods of the National Center for Health Statistics which uses 10 year age groups from age 5 through 85. The age distributions of the US standard populations are shown below.

US Standard Population Proportions

1970		1940	
age group	proportion	age group	proportion
0 - 4	0.0844	<1	0.0160
5 - 9	0.0982	1 - 4	0.0641
10 - 14	0.1023	5 - 14	0.1703
15 - 19	0.0938	15 - 24	0.1817
20 - 24	0.0806	25 - 34	0.1621
25 - 29	0.0663	35 - 44	0.1392
30 - 34	0.0562	45 - 54	0.1178
35 - 39	0.0547	55 - 64	0.0803
40 - 44	0.0590	65 - 74	0.0484
45 - 49	0.0596	75 - 84	0.0173
50 - 54	0.0546	85+	0.0028
55 - 59	0.0491		
60 - 64	0.0424		
65 - 69	0.0344		
70 - 74	0.0268		
75 - 79	0.0189		
80 - 84	0.0112		
85+	0.0074		

Direct method of age adjustment

Multiply the age-specific rates in the target population by the age distribution of the standard population.

$$\hat{R} = \sum_{i=1}^{m} s_i (d_i / P_i) = \sum_{i=1}^{m} w_i d_i$$

Where m is the number of age groups, d_i is the number of deaths in age group i, P_i is the population in age group i, and s_i is the proportion of the standard population in age group i. This is a weighted sum of Poisson random variables, with the weights being (s_i / P_i).

Confidence Intervals

Confidence intervals for the age-adjusted rates were calculated with a method based on the gamma distribution (Fay and Feuer, 1997). This method produces valid confidence intervals even when the number of cases is very small. When the number of cases is large the confidence intervals produced with the gamma method are equivalent to those produced with the more traditional methods, as described by Chiang (1961) and Brillinger (1986). The formulas for computing the confidence intervals are given below. Although the derivation of this method is based on the gamma distribution, the relationship between the gamma and Chi-squared distributions allows the formulas to expressed in terms of quantiles of the Chi-squared distribution, which can be more convenient for computation.

$$\text{Lower Limit} = \frac{v}{2y}\left(c^2\right)^{-1}_{\frac{2y^2}{v}}(a/2)$$

$$\text{Upper Limit} = \frac{v+w_M^2}{2(y+w_M)}\left(c^2\right)^{-1}_{\frac{2(y+w_M)^2}{v+w_M^2}}(1-a/2)$$

where y is the age-adjusted death rate, v is the variance as calculated as shown below, w_M is the maximum of the weights s_iP_i, $1-a$ is the confidence level desired (e.g., for 95% confidence intervals, a = 0.05), and $\left(c^2\right)^{-1}_x$ is the inverse of the c^2 distribution with x degrees of freedom.

$$v = \sum_{i=1}^{m} d_i\left(s_i/P_i\right)^2$$

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Chiang, C. L. Standard error of the age-adjusted death rate.*Vital Statistics, Special Reports* 47:271-285, USDHEW, 1961.

Fay, M.P. and E.J. Feuer. Confidence intervals for directly rates: a method based on the gamma distribution. *Stat Med*16:791-801, 1997

Appendix B: Sources of Additional Information

For more information on cancer, risk factors or prevention strategies please refer to the following resources:

1-800-4CANCER: A cancer information service of the National Cancer Institute

American Cancer Society, Western-Pacific Division: 1-800-729-1151 ext. 3307
American Cancer Society. 1997 Cancer Facts and Figures

National Cancer Institute. PDQ Detection and Prevention Website (http://icicc.nci.nih.gov/clinpdq/screening.html). September 1997.

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Washington State Department of Health. Health of Washington State. September 1996.

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